MOTION CONTROL RIG
SAFETY MANUAL

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Summary

This manual describes the safety aspects of the **Mark Roberts MILO Motion Control Rig** and **Model Mover System** and their use. This document also acts as a guide to safety aspects of other Mark Roberts Motion Control Equipment. Some additional details of other specific rigs are covered in chapter 9.

It is important that the user keeps up to date with any revision to the equipment design that affects the contents of this manual and amends safety procedures accordingly.

KEY POINTS

- The Owner and User are jointly responsible for the correct and safe use of the equipment, taking into consideration the guidance provided by this manual.

- Safety legislation and recommendations are well documented in summary and in detail in HSE (Health and Safety Executive) and other documents including those in the list of references. This safety manual is additional to these references- which together provide essential safety education.

- The equipment is electrically powered and controlled by the operator with the assistance of the computer and electronics. Therefore its operation requires strict safety procedures in normal operation.

- Safety is dependent on knowing the hazards and controlling and minimising these hazards. It is the responsibility of the Employer of the personnel to define, formalise and conduct safety training and safety procedures for these personnel.

- This Safety Manual is a guide to safe use of a Mark Roberts Motion Control rig and does not cover all aspects of operating a rig, or describe in detail all its safety features and their proper operation. It is intended to complement a full period of Instruction by a Qualified Operator or Service Engineer, where all aspects of assembly, dismantling and safe operation are covered in detail to full understanding. This manual should always be accompanied with lots of common sense.

As in the case of any power-driven equipment, safety is of vital importance to all persons working in or passing through the operating area of the rig. It is therefore essential that the Owner and Users consider all necessary safety aspects of the use of the equipment in their chosen applications and ensure that adequate safety procedures are always used.

The equipment is a **semi-automatic moving device** which must remain under the supervision and control of the designated and authorised operator. The operator must also ensure that the equipment is placed in a safe state and made secure against casual tampering or accidental activation, whenever it is not under his control.

The equipment by its nature involves inherent hazards which are wholly dependent on the care taken by the operator, and in some cases on the other personnel in the area. The operator must be knowledgeable as to the normal running of the equipment as well as being vigilant as to any type of malfunction or system fault. Under fault conditions the operator must take the appropriate action(s) to render the equipment safe.

Suitable safety training of personnel is mandatory and must cover the important details in this manual. It is the responsibility of the Owner and Users to ensure adequate training as covered by safety legislation. The training must include the safe setting up, use and maintenance of the equipment. It is especially important that the operator(s) themselves are adequately

trained on the standard methods of setting up, operating and dismantling the equipment so that they can supervise and check these procedures.

The equipment has various **safety features** built into it to significantly reduce the risks of or from malfunction or of travel beyond established limits. It is vital that these features are operational and are not overridden deliberately or accidentally. Operating the equipment where a fault exists in a safety feature would expose the users to higher levels of risk. Consequently routine verification of these safety features by the owners and users is vital, followed by immediate remedial actions as needed.

ALWAYS, ALWAYS, ALWAYS, AND ALWAYS

The following points should always be observed, many are covered in more detail in the following chapters:-

1. Always check the rig is mechanically sound when operating it.
2. Always check cables are properly routed and connectors are fully and correctly plugged in.
3. Always check the mains voltage settings are correct.
4. Always check for obstructions before allowing the rig to move.
5. Always watch the rig, not the video feed.
6. Always make sure the environment of the rig is correct for its proper operation, particularly temperature, humidity, direct water contact, dust etc.
7. Always enable all available software safety features:
    - **Never operate the rig with the E-stop override key plugged in. This is for testing only.**
    - Always use the buffers, do not remove them.
    - Always use the magnetic/optical end limits, do not remove them.
    - Always set the software limits for the axes correctly.
    - Always set which axis has a brake, in the software.
    - Always set and enable the use of the speed-sensing tachometers if they are available.
    - Always allow the software to fully start and reach a “Ready” state before disengaging the E-stop.

Glossary

This section defines important terms used in this manual. The details here need to be understood as part of the rig safety training.

ACCESS
The **user** is responsible for controlling **access** of all personnel to the operating zone of the **equipment**. **Access** includes moving into the space that the equipment moves through as well as the opportunity and/or permission to handle the equipment.

BRAKES
Electrically disengaged brakes ('fail safe') fitted to those axes that need this means to freeze them on removal of motor power. The brakes are energised (i.e. brake off) when the axes are **engaged** to run.

BUFFERS & END-STOPS
The combination of solid end-stop and shock absorber 'buffer' installed on specific axes to mechanically limit the axis' travel.
These are required at the ends of travel. On Track and Lift axes the end stops can be positioned to give a reduced length of travel for greater safety. They must not be left off or wrongly positioned. The setting up of the rig should be such that it does not run hard into the buffers under normal running.

CREW
The people immediately involved in the shoot including director, technicians, actors etc.

ENGAGED/DISENGAGED AXIS
An **engaged axis** has its power amplifier enabled and its **brake*** off. Disengaging the axis disables the amplifier and causes the **brake*** to engage. (* **brakes** are only present on certain axes). A **disengaged axis** is also referred to as **tripped**.

EMERGENCY STOP ('E-STOP')
The manual or automatic removal of primary DC power to the rig axes so as to bring the rig to a rapid stop. Power is also removed from the **brakes** allowing them to operate.
(see also **stop**)

EMERGENCY STOP CIRCUIT
The powered circuit that passes through the rig from the e-stop button on the console. When this circuit is broken it allows a set of electrical contacts to open . This removes main power from all axes thus causing an **emergency stop**.
The option exists for the **user** to link in a dedicated **e-stop circuit (**per **manufacturer's** design) to further e-stop buttons sited at the edges of the operating zone , based on their safety assessment and safety procedures.

EMERGENCY STOP UNIT
The large red push-button unit that is the main point for initiating an **emergency stop**. It also includes the (smaller) reset button (which is pressed when power is to be restored to the rig axes).

EQUIPMENT
This includes the motion control rig, operator interface and **model mover** or **remote head** (where used).
The equipment is 'work equipment', as covered in the HSE (Health & Safety Executive) reference listed and the employer legal obligations stated there apply.

HAND-HELD BOX (HHB) (or JOG BOX)
A moveable operator interface with joy-sticks and a key-pad plus a button to initiate an **e-stop.**

ISOLATION
The removal of all mains power from all parts of the equipment or section of the equipment to render it electrically safe and inactive (e.g. for intrusive maintenance).
Note: energy takes about a minute to drain from capacitors after **isolation**: camera batteries where used remain live regardless of mains isolation.

LIMITS ('HARD LIMITS') (see also '**soft limits**')
Electrical Sensors fitted to axes to define their position and limit of travel to the software. The **hard limits** on an axis can include both datum and end limits. These limits are interrogated within the electronics and software and the end **limits** must be positioned so as to cause the software to disengage the relevant axis (thus stopping its motion abruptly).
The operator is required to position the **end stops** to suit the required length of travel and to adjust the **hard limits** according to the defined options (see chapter 4.0). The **soft limits** should be set to keep travel within these constraints and avoid axis trips and fast collisions with the buffers.

LOSS OF POSITION
(see **zero position**)

MANUFACTURER
MRMC- the manufacturers of the motion control rig

MODEL MOVER
A set of axes used to move a model or object quite separate from the camera and its axes. Its relative safety depends partly on the speed and power of these axes. The model mover is normally set up by the **user** in many different configurations.
This flexibility requires the **user** to ensure safety aspects are all addressed in each case.

OPERATOR
The trained and authorised individual who is designated to be in overall charge of the rig movements. He is responsible for the initiating and stopping of every move of the rig including the control of access to the hand-held box and to initiating 'triggers'. He ensures that the **emergency stop unit** is in his reach whenever the rig is powered up and is not fully e-stopped.

OWNER
The organisation or individual who owns the motion control rig.
Both **owner** and **user** must each address the various safety issues in this manual and identify their individual responsibilities and actions.

PERSONNEL
This includes all individuals having access to the operating zone of the equipment, whether casual visitors or hired staff, crew, actors etc.
The **user** is required to exclude all unauthorised personnel from the operating zone.

REMOTE HEAD
A camera head mounted separate from the main rig. Its main axes are PAN ,TILT and ROLL.

RIG
This refers either to the moving part of the **equipment** or the whole **equipment** depending on the context.

SAFETY FEATURE
An aspect of the equipment design that is included to address or enhance safety. Temporary or permanent failure of a **safety feature** must be attended to before the rig is run any more.

SAFETY PROCEDURE
A formally established sequence of actions required to be followed for safety reasons. The **user** is responsible for establishing and using adequate **safety procedures**. These need to include an understanding and checking of the rig **safety features** as well as general safety aspects and need to address the recommendations in this manual.

SOFT LIMIT
Numerical values (axis positions) entered in FLAIR software to define the required range of travel of an axis in relation to the axis **zero position**.
These are used by the software to slow the axis when the **soft limit** is reached**.** Correct **zeroing** is essential to this action. (see **zero position** an chapter 4 for details)
NB: **soft limits** are ignored during pre-roll, postroll and when the axis is controlled by a mimic unit as well as in cartesian control mode.

SPEED SENSING
Certain axes have the extra **safety feature** called **speed sensing**- which is a tachometer measurement of the axis movement. This is used to alert the software to faulty movements of the axis i.e. at the wrong speed. In particular a stationary axis is faulty if it does not measure zero speed.

STOP
The software action that slows the equipment to a controlled halt without removing power from the axes- i.e.: without an **e-stop.**
Stopping the rig using the **e-stop** is not recommended except when needed for emergency reasons.

TRIPPED AXIS
(see **engaged/disengaged axis.**)

USER
The organisation or individual who is using the motion control rig and organises its operation. The user is responsible for authorising and supervising their chosen **operator** for each shoot as well as controlling **access** to the equipment and operating zone.

ZERO POSITION , ZEROING (and LOSS OF POSITION)
The software keeps an exact value of the position of each axis as a measurement from the axis **zero position**.
To do this the software must read the chosen zero position (called zeroing) .The software must then continue to record every precise axis movement from that point.
If the software does not get the precise position update it needs for the axis it trips the axis due to its **loss of position** (i.e. the software holds a different- and incorrect- position from the actual one.)

Abbreviations

AC	alternating current
BS	British Standards
DC	direct current
E-stop	emergency stop
HHB	hand held box
HSE	Health and Safety Executive
LED	light emitting diode
MRMC	Mark Roberts Motion Control
PC	personal computer

1.0 General

1.1 The Motion Control Equipment is designed for operation by a trained operator who sets up and operates the rig via the operator interface console plus hand-held box. The equipment runs on dedicated track and requires adequate clearance for all its required movements.

1.2 The equipment must be set up in a safe manner and its safety features and error-free operation verified. It is designed for film and video motion control use in its standard configuration. It is not intended for other applications. User modification and interfacing is outside of the scope of this guide and is inadvisable unless the user is able to ensure all safety requirements are maintained for the entire system established.

1.3 The equipment must be protected from water condensation, rainfall, dust, chemical or vapour ingress or accumulation of any of these .

The main parts of the moving rig are designed to minimise penetration by precipitating dust and moisture. However, use in an environment which is not protected from the weather and pollutants requires both storage and operating precautions to achieve the above.

Electrical safety can only be maintained for the whole system by the owner and user ensuring that protection is effectively achieved and electrical hazards are correctly addressed.

The equipment will deteriorate if placed or kept in an uncontrolled working and storage environment . Should such conditions be encountered it is essential that significant levels of moisture, dust etc are eliminated before deterioration results and before the equipment is run. This includes the elimination of internal condensation if it has been impossible to prevent this.

1.4 The equipment must also be protected from extremes of temperature, electromagnetic or other radiation and from mechanical impact and abnormal stress.

It is essential that under increased heat load (very hot weather/air/illumination etc) the equipment can maintain adequate cooling- for which purpose internal fans are fitted. If the air is too hot or the airflow too slow or restricted equipment overheating is likely. Likewise it is essential to avoid other external influences such as those listed above which are capable of interfering with the operation of the equipment.

1.5 The connection and removal of electrical power (and hydraulic if applicable) must be done in a safe manner at the correct point in the set-up and break-down sequence. Extra care is required for any powered movement and for access to the equipment and its vicinity throughout these sequences.

2.0 Safety Features

The following is a list of the main safety features incorporated in the MILO mark 3 Motion Control Rig:-

paragraph	***safety feature***
2.1.	Hard end stops and buffers
2.2	End of travel 'hard' limits
2.3.	Emergency stop circuit
2.4.	Brakes
2.5.	Axis trip on loss of position
2.6	Speed Sensing
2.7	Current limit and current trip devices
2.8	Hand-Held Box inhibit
2.9 .	Guards and Electrical Enclosures
2.10.	Electrical Isolation
2.11	Safety Earth

Checks on the above are part of the essential routine both on setting up and on running the equipment.

The features and typical checks are as follows:-

2.1. Hard end stops and buffers

Track: two end stops at each end of track, positioned to meet buffers fitted to the ends of the rig base.
Lift: end stops with adjustment to limit bottom of travel. fixed lower buffers. upper buffers can be attached in three different positions to give different heights of lift.
Extend: one fixed end stop for each direction of travel ,meets a pair of buffers.
On Lift and Extend the buffers are adjusted to factory-set positions.

Checks:-

All stops and buffers securely in correct positions and each axis inched up to, to visually check alignment and function.

2.2 End of travel 'hard' limits

These employ a moving magnet and fixed sensors. The hard limits define the axis' position and travel for the software. The **limits** are interrogated within the electronics and software and the end **limits** should cause software to disengage the relevant axis thus stopping its motion abruptly.
The operator is required to position the **end stops** and **buffers** as above to suit the required length of travel and to adjust the **hard limits** according to the defined options (see chapter 4.0). The **soft limits** should be set to keep travel largely within these constraints and avoid axis trips and fast collisions with the buffers. (see **soft limits** in '**terms'** above)

Checks:-

Axis inched past end limit till axis disengages (this may require temporary modification to the zero setting using the direct zero option- FLAIR software manual chapter 18). Position confirmed correct visually. Ensure axis is correctly zeroed afterwards.
Sensing can also be examined on the PC.

2.3. Emergency stop circuit

ref. drawing 3/000/7004

This circuit requires a manual reset at the e-stop unit with the button raised and the

circuit fully made. The key for the key-switch is only for maintenance use and must not be left inserted in the unit.
The reset must be visibly and audibly functional as follows:-

Checks:-

- **first ensure that the removable key is not inserted in the unit.**
- now check each method of initiating the e-stop below:-

- Without e-stop depressed and after reset engaged axes move on demand. E-stop unit LED's remain on. Amplifier green LED's are illuminated and axis board green LED's are illuminated for all engaged axes.
- Depress e-stop button. E-stop unit LED's extinguish . Power Supply contactor is heard to drop out. Engaged axis green LED's on amplifiers extinguish. Axes will not engage or drive but stay motionless.
- Raise E-stop button. E-stop unit LED's remain off. Reset e-stop circuit. E-stop unit LED's illuminate. Amplifier green LED's illuminate . Axes that are engaged in FLAIR software have axis card green LED's on.
- Momentarily depress e-stop button on HHB and check as above.
- Confirm that on starting the software afresh, even with the e-stop button raised and e-stop circuit reset, an e-stop is caused and the e-stop circuit requires a new reset.

NB: an e-stop during a high-speed move should only to be used as a real emergency action. Where there is adequate time to stop the rig safely and there is not a serious hazard use the 'stop' and 'quick stop' functions in preference.

2.4. Brakes

These are applied to specific axes when the relevant brake is de-energised. They are used to prevent the axis from moving while the motor is unpowered.

Checks:-

Observe that brakes are fitted on the relevant axes as defined.
Confirm that any belt drives are not worn or damaged and are correctly tensioned.
NB: when performing the following tests on axes that rise and descend, ensure these axes are close to their lowest positions.
With suitable safety precautions, with each relevant axis initially engaged, disengage each of these axes in turn and confirm they remain held firmly in position and cannot be moved by hand. Depress the e-stop and make the same checks.

2.5. Axis trip eg: on loss of position

ref.: drawing 4/000/7007

The axis is engaged when the software gives an enable signal to the amplifier. The amplifier then powers the axis motor. The axis position is shown dark on the PC screen while it is engaged, and light grey when it is tripped.
The software normally maintains a precise measurement of the axis position. If the axis fails to keep exactly to the position required by software ,the axis is tripped as the software views this as a **loss of position**.

Checks:-

Axes must engage and disengage manually via the main software screen and axis card green LED. The brake (if any) audibly clicks. The axis board green LED's illuminate to show engaged axes.

Press down the e-stop. Observe that the green led on the axis board for a chosen axis is on and the position is dark on the screen. attempt to move the axis with the HHB. The position display changes number and goes light grey and the axis board green led goes out- showing a trip due to **loss of position**.

2.6 Speed Sensing

Certain axes have the extra **safety feature** called **speed sensing**- which is a tachometer measurement of the axis movement. This is used to alert the software to faulty movements of the axis i.e. at the wrong speed. In particular a stationary axis is faulty if it does not measure zero speed.

Checks:-

Verify that tacho's are connected and that speed sensing is active for relevant axes per the menu 'axis safety' in software.

2.7 Current limit and current trip devices

These include fuses and circuit breakers as well as electronics in the amplifiers.

Checks:-

Verify that the correct fuses are fitted in the equipment (including mains plugs) whenever these are replaced. Investigate any fuse failure or circuit breaker trip that is repetitive.

Observe any LED indication of failure due to excessive power demand and act accordingly per drawing 3/000/7004.

2.8 Hand-Held Box inhibit

This is a feature in the software that inhibits the functions of the HHB (Jog Box)

Checks:-

Confirm that the hand-held box is not functional until enabled via the main operator interface (PC) (see right side of screen). Disable the HHB again on the PC and confirm HHB is now unresponsive. Leave disabled till next required.

2.9. Guards and Electrical Enclosures

These include covers fitted to prevent access to mechanical and electrical hazards. The moving or active rig should not normally be touched due to the various hazards it presents. Guards and enclosures minimise the risk of accidental contact with moving gears and belts or live parts. Hazardous AC & DC voltages are present within the confines of the equipment. ***These must not be exposed to manual contact while live.***

Checks:-

The rig is designed to operate with all covers and guards in place and without manual contact to the rig itself or rails during movements (with special noted exceptions). Ensure that all guards and covers are in place with all fastenings present while the rig is in use. Safety procedures must be used whenever there is a need for authorised maintenance personnel to remove any guard or cover, with full regard to any safety hazard exposed. Electrical Isolation is needed in most cases.

Cables and connectors must not be damaged nor should they be powered while disconnected

2.10. Electrical Isolation

This feature is a safety requirement to be implemented by the user per commissioning data. ref. drawing 3/030/0010.

The rig is to be connected to a single mains source via the several mains plugs that supply the rig, model mover and/or remote head. This source is to be located at a single labelled position Fuses in these plugs break under excess current conditions. The user is required to provide a single means of manually isolating the mains supply to the rig, which should render it motionless and to a large degree safe.

Checks:-

Confirm that the method and route of mains power is clearly and correctly achieved and

labelled with the required means of isolation. Confirm that full isolation is achieved to all rig systems using the designated isolating switch..

2.11 Safety Earth

The mains feeds to the equipment each include safety earth conductor. The metalwork of the main parts of the equipment is bonded to the safety earth conductor so that a voltage different to earth potential will, if shorted to the metalwork, draw a current and blow a protective fuse or breaker- instead of making the metal live.

It is essential that the user ensure that the earth conductors all connect to the mains earth and this earth is tested and meets regulations.

Checks:-
Confirm all earth conductors at primary mains connector outlets are low resistance and meet wiring regulations for the power of the outlet.
Prior to plugging in equipment, confirm low resistance of each earth conductor from rig/equipment metalwork through to earth pin on mains plugs.

2.12 General

Any mechanical damage to the equipment or symptom of malfunction requires examination to ensure that the safety features or normal function are not impaired.
Belt drives must be in good operating condition: if they are damaged or worn they must be replaced and must be correctly tensioned and aligned.

3.0 Setting Up Equipment

3.1 Transportation

The equipment is transported as a set of sub-assemblies. These must be assembled fully and correctly per this summary -and detailed more fully in the user's manual- before the equipment is powered up and prepared for powered operation.
The mains supply voltage must be correct for the equipment as set up (it can be wired for 240 volts ac or 110 volts ac within the Power Supply units).

3.2 Operating Space

The equipment requires full clearance around the extent of its track, including up to the highest camera platform reaches. Where such full clearance is not achievable, the operator must ensure that any manual or automatic move does not result in a collision of the rig with a wall(or ceiling or floor) or an obstacle or pass too close to personnel. Adequate space provision is needed for all personnel to be able to move clear of the travelling rig and its operating zone.

End stops, hard limits and soft limits all have a part to play in the above and need to be set up suitably as covered below.

3.3 Environmental Conditions & Equipment Condition

If the equipment is not stored and used in suitably controlled environmental conditions, ensure that means are available to keep out the weather etc. Ensure the equipment is dry and clean and free of condensation etc when assembling and when powering up. Do not expose the unprotected equipment to severe environmental conditions.

3.4 Assembly

Each sub-assembly including the track sections involve lifting and require safe lifting practices (reference:' Manual Handling'- HSE). The weight of each sub-assembly needs to be examined and sufficient personnel or suitable lifting gear are required. Suitable holding points must be chosen.

3.4.1 Track

The track must be firmly and securely laid and fully levelled, with each track join flush and secure. The supporting surface for the track must be adequate to fully support the dynamic load of the full rig without deflecting or tilting. All screws and adjustments must be tightened, but not over-tightened.

Each end of the track must be fitted with end stops.

3.4.2 Base, Turret

As the rig is assembled each sub-assembly must be made secure before the next sub-assembly is added. The sub-assemblies such as the main arm and outer arm need to be positioned such that they are not relying heavily on their drive mechanisms and brakes to maintain their positions (see also next paragraph) until the equipment is fully assembled and personnel are clear. Belt drives must be correctly tensioned and must not be damaged or worn. Personnel should not stand directly under the arm or head, especially during setting up.

3.4.3 Brakes

The following rig axes employ motors with drive mechanisms and brakes which are essential to the support of the main arm, outer arm and head. These features must be checked as the rig is assembled:-

LIFT: motor, belt drives, lead screws and brakes- supporting main arm.

EXTEND: motor, belt drive, gearbox and brake.
OUTER ARM: motor, gearbox, engagement spring, belt-drive and brake.

NB: The head itself may employ brakes on its three main axes (pan, tilt, roll) and needs to be checked to ensure they remain held in position.

3.4.4 Limits

Limit switches (zero and end-limit) must be suitably positioned for each major axis during the setting up procedure. For the track and other linear axes these are required to ensure the drive is disengaged on that axis when the rig is driven close to the end stops.

3.4.5 Power-up Sequence

Whenever the system needs to be powered up use the following sequence:-

1. Make sure the power supplies and operator interface are set correctly for the mains supply you are using.
2. Make sure all cables are fully connected in the correct place.
3. Make sure the E-stop is fully depressed. And that the testing key has been removed.
4. Make sure the mains switched and circuit breakers on the power supplies are off.
5. Apply power to the operator interface (PC etc.)
6. Apply power to the power supplies.
7. Switch on the line of mains switches on the power supply.
8. Switch on the line of circuit breakers on the power supply.
9. Fully load the software.
10. Disengage the E-stop. The green lights on the amplifiers should come on.
11. Enable the axes. The green lights on the axis board should come on.

3.5 Assembly Sequence

IMPORTANT: DO NOT APPLY POWER TO THE EQUIPMENT UNTIL INSTRUCTED IN THIS SEQUENCE. DO NOT CONNECT OR DISCONNECT POWERED-UP PLUGS AND SOCKETS.
ENSURE ALL POWER SUPPLY UNITS PLUS THE OPERATOR INTERFACE ITEMS ARE SET FOR THE MAINS VOLTAGE AVAILABLE. (drawing 4/900/6013 is normally displayed within each power supply unit to indicate the wire linking required in each case).
ENSURE THAT THE DESIGNATED OPERATOR TAKES CHARGE OF THE RUNNING OF THE EQUIPMENT VIA THE OPERATOR INTERFACE AND E-STOP AT POWER-UP, IN ADDITION TO SUPERVISING THE ASSEMBLY.

3.5.1 Summary

A. Ensure all **mains voltage settings** are correct to the available mains supply. This will include changes to wire links in the power supply units when changing from 110 volts to 240 volts and vice versa
B. The **operator interface** can be set up first or otherwise early in the sequence

C. Lay the **track**

D. The **base** must be placed on and secured to the track (including cam-followers on Moy rails).

E. The **turret** is then placed on the base and secured to it.

F. The **power supply tray** is fitted to the side of the turret and the power supply and driver unit are placed on it.

G. The **lift arms** are attached to the turret.

H. The **main arm** is fitted to the turret.

I. The **outer arm** is connected to the main arm.

J. All equipment **cables** are now connected as per the user manual (summarised in drawing 3/030/0010)

K. At this point the rig should be **powered up** and run using routine tests to verify its correct performance as per the pre-checks in 3.6 below. [This needs to include verification of the main safety features. Being able to move the rig axes under power will assist in completing the assembly. Exercise extra caution in regard to safety and rig operation until the rig is fully assembled, set up and tested. Setting up the HHB, scaling, limits etc are vital to safe running of the powered rig.]

CAUTION: DO NOT CONNECT OR DISCONNECT POWERED CONNECTORS. REMOVE POWER FIRST. SHOULD ANY CONNECTOR BE LEFT DISCONNECTED (WHERE PERMISSIBLE) IT MUST BE PREVENTED FROM SHORTING OR PRESENTING AN EXPOSED RISK OF SHOCK).

L. The chosen **head** is connected to the outer arm.

M. Power up the **full system** and verify outer-arm and head axis performance.

N. Zero all axes excluding the camera.

O. The **camera** is now fitted to the camera platform and made fully secure. If the camera does not yet have a lens fitted, one is now added together with any needed support bars (matt bars).

P. test the **camera axes**

Q. test **moves**

NB: The Hand-Held Box is able to be modified in software for non-routine functions. The HHB user must verify the HHB functions both during setting up and as he uses each control during normal use. Caution is needed in the use of high speed settings. Guard against inadvertent joystick actuation.

3.5.2 Assembly sequence- Detailed Procedure:-

A OPERATOR INTERFACE and MAINS VOLTAGE SETTINGS
The operator interface requires a single location to provide all power to the equipment including the rig. The operator interface is fully connected together per diagram 3/930/0011 sheet 2 and will be connected to the rig via the umbilical as part of the sequence below. The operator must ensure that the correct FLAIR software is loaded into the computer together with the correct settings (configuration). The software used by the rig will be downloaded when the rig is powered up.
Ensure all **mains voltage settings** are correct to the available mains supply. This will include changes to wire links in the power supply units when changing from 110 volts to 240 volts and vice versa. Label the outside of the units clearly with the voltage set. (ref. drawing 4/900/6013)

B TRACK
Lay the track and clip together ensuring that the joins are fully seated.
Level the track.

Lay the racking, limit blocks and datum block.
Adjust the racking.
Fit the track buffers.

C BASE

The base is then placed on the track by way of the lifting bars (as supplied by the manufacturer).
NB: If four people are used in this operation, the lifting action must be synchronised to prevent the base from tilting suddenly.
Ensure that the track drive mechanism is on the correct side so that it will not foul on the racking when the base is lowered into position.
Once lifted, approach to the track should be from one end, thus preventing the need to walk across the rail with the load.
Once over the rail, lower gently and adjust the track gearbox's position prior to placing it on the rail.
Verify positioning of track end stops.
Adjust track tensioning wheel.
If using standard track, fit cam-followers.

D TURRET

The turret is then placed on the base by way of the lifting bars (as above).
NB. Position the Turret such that the connectors will be on the correct side of the track and that all loose cables are strapped up, prior to lifting.
Ensure that the rotate pinion is fully retracted (un-meshed) prior to lifting.
Ensure that the stainless steel shoes are fully retracted prior to lifting
If four people are used in this operation, the lifting action must be synchronised to prevent the turret from tilting suddenly.
Once lifted, approach to the base should be from one end of the rail, thus again preventing the need to walk across the rail with the load.
Ensure that the rotate pads are fully seated once the turret is in position.
Push shoes into their clamping position and bolt down firmly.
Position the rotate at 45 degrees from the track towards the near end, and mesh the rotate pinion.

E POWER SUPPLY TRAY

Fit power supply tray to the turret.
Place the power supply unit on the tray.
Place the driver unit onto the power supply tray.

F LIFT MECHANISM

Fit the lift ball-screw units to the turret such that the arm will be close to level.
Engage the support plate to the ball-screw unit and secure firmly.

G MAIN ARM

If the Milo has no extend:

Arm cables should be strapped up over the rear of the arm.
Position one person at each corner of the arm.
Lifting of the main arm must achieve shoulder height if the operation is to be completed successfully.
Lift the arm and place the back end on the front blocks of the support plate.
Edge the arm forwards until roller bearings facilitate sliding the arm backwards into the position required. Ensure that the arm is correctly aligned and seated.
Secure firmly.

If the Milo has extend facility:

Arm cables should be strapped up over the rear of the arm.
Position one person at each corner of the arm.

Slide the bearing blocks to the rear of the arm.
Lifting of the main arm must achieve shoulder height if the operation is to be completed successfully.
Place the rear of the arm on the support plate such that the front bearing blocks on each side will support the load.
Gently slide the arm backwards until rear bearing blocks can be seated into position. The arm can be manoeuvred by tipping it downwards to avoid obstacles .
The persons from the rear should secure the rear of the arm to the main-shaft while the arm is still supported.
The arm should then be fully seated, and secured firmly both front and back.

H OUTER ARM

note: This may be fitted now or may be fitted along with the head below.

Ensure that the angle pinion is fully retracted.
With one person either side, lift the head and angle unit, align key slots and slide into place.
Secure firmly.
Re-mesh the angle pinion.

I CABLES

Connect up all cables.
Ensure that there is sufficient slack cable for the extend and lift axes at the rear of the turret.
Connect umbilical to turret and clamp umbilical to base.
Unroll the umbilical fully and with one loop attach it to the console section.

J TEST RIG WITHOUT HEAD

K HEAD

Ensure rig is fully e-stopped and axes disengaged.
Attach the chosen head.
Confirm that the amplifiers in the upper driver box are correct for the head.
Connect the camera 12volt or 24 volt feed as needed to the main arm distribution box per drawing 4/530/6008.
Ensure that the appropriate software is loaded.
Adjust buffers, end stops, hard and soft limits to suit head.

L TEST HEAD

M CAMERA

Ensure rig is fully e-stopped and axes disengaged.
Fit camera securely to camera platform including matt bars and base. Support heavy lenses securely with a bracket on the matt bars.
Connect camera and lens motors with appropriate cable.

N TEST CAMERA

O TEST MOVES

3.6 Routine Pre-checks

Routine pre-checks should be carried out on the equipment and the software to validate its correct functioning and point to any problems or possible problems at an early stage. These should be done before powering and when first starting up the system. These include checking the following:-

Correct connection of all cables

Check cables are plugged into the right place, that they are fully located, and not twisted or

pulled tight or too slack (to the point of catching on something.

Mechanically sound
Check to make sure end stops are all in place and securely fastened, make sure the various bolts are fully tightened.

Operator Interface
Check the software settings are correct, particularly axis setups. And that the safety features have been enabled correctly on the various relevant axes.

Zeroing Axes
Before zeroing axes make sure there are no obstructions around the rig. Make sure the axes are roughly in their zero positions or else the zeroing process may fail. Make sure that zeroing the axes brings the axes to the right positions.

Smooth Running
Check that when moving axes they run smoothly and there are no mechanical problems indicated by rough sounds, knocking or rubbing sounds.

4.0 Using Equipment

4.1 Preparation

The equipment must be fully assembled and set-up as covered in chapter 3 before it is put to use. The operator must be sure that the equipment is in a known and fully set-up and connected state before he begins to run moves . This also applies after the equipment has been powered down etc .

With the correct software and set-ups loaded and checked, the operator uses the operator interface to run moves. This interface gives him several methods of operator interaction as listed in 4.3 below.

NB: If the operator has more than one version of software or equipment configuration, extra care is needed to ensure the correct combination is used. The relevant parts of chapter 3 'Setting Up Equipment' must be performed for each such change.
The operator must perform routine tests of the safety features as listed in chapter 2 at suitable intervals and monitor for any indication of a malfunction during normal running of the equipment.

4.2 Routine Actions

The operator must keep within arm's reach of the e-stop unit as long as the rig is powered up and is not fully e-stopped. He should return the rig to its zero position or a neutral position and disengage the axes as well as fully e-stopping if he is going to be away from the console.

The operator must continue to ensure that the equipment is not subjected to or affected by unsuitable environmental conditions, and must provide extra protection when needed. This may also require powering down the equipment.

4.3 Operator Interface

4.3.3 Emergency Stop

a) Emergency Stop Unit

b) HHB emergency stop button

4.3.2 Personal Computer

c) VDU with FLAIR screen

d) Keyboard

e) Mouse

4.3.3 Hand Held Box

f) keypad

g) joysticks

4.3.4 Mimic Unit

f) hand-wheels

4.3.5 Video Monitor

i) video image from camera

4.4 Running Moves

The operator performs routine pre-checks on the equipment during the working day, to keep himself informed of its status and correct behaviour. This includes checking the function of the 'e-stop' (see 'routine pre-checks' in section 3.6).

The operator keeps the equipment fully 'e-stopped' except when he is actively supervising and running moves and has the e-stop unit within arm's reach.

The operator must maintain control of the operating zone and personnel and keep the personnel informed of what moves are being run and when. He must announce the start of each move, having made sure that there are no personnel or objects in the rig's path. Standing on or very close to the track, especially before or during moves is hazardous and is to be avoided.

The operator must set up each move, ensuring that no collision occurs. NB: 'near misses' are to be avoided wherever possible and require especial care to ensure no collision occurs. The operator must be aware of and be prepared for the effect produced by a tripped axis or the use of a 'goto', as these modify the path of the move, as do changes to scaling, pre-roll, post-roll, re-calculating the move with different settings including adding or subtracting way-points etc.

The operator must re-adjust soft and hard limits buffers and end-stops as appropriate where these are able to provide improved safeguard against over-run and/or collision.

The operator must observe the movement of the rig itself, (it is not safe to do this by means of the video image from the camera). He must ensure that blind spots are not a problem (e.g. zones obscured to his view by the rig or props). These actions require especial care on the first pass of a move and after modifying a move.

The operator must ensure that all axes are correctly zeroed before moves are run. He must re-instate these zeroes if the rig position is lost or the zero settings are erased or modified in software. Zeroing is performed regularly under various circumstances, including after rig power-up to ensure correct settings.

The operator must regulate the use of the HHB. He only activates the HHB when it is in active use by himself at the console or under his supervision. The user of the HHB must exercise the same care as the operator himself and seek help and advice from the operator as needed. The choice of HHB speed setting must always be allowed for and should only be set high while this speed is essential.

4.5 Breaks From Operation_

When the rig is to be left unattended for a break in shooting, the operator must position the rig in its zero position or a neutral position and disengage the axes as well as fully e-stopping.

5.0 Equipment Maintenance

5.1 Both routine and remedial maintenance must be performed on the equipment by suitably trained personnel. The user must ensure that such maintenance occurs so as to keep the equipment in full working condition. A maintenance log is to be kept by the user to record all maintenance matters.

Suitable warning signs must be displayed on or near the equipment while it is under maintenance to inform users who may put maintenance or other personnel at risk without this information.

Extra safety measures are needed during maintenance actions. The user must follow the standard replacement procedures defined in the hardware manual for routine actions and confirm correct operation of safety features following maintenance. All other maintenance requires appropriate training and methods to ensure that the equipment is kept safe and correctly configured.

Routine Maintenance includes a set of operational checks plus exchange of standard modules, cables and/or software. Each requires partial or complete shutting down of the equipment before and powering up after, with appropriate pre-checks.

5.2 Replacing parts

The following is a list of routine replacement actions and the precautions involved:-

General Precaution: Set all axes to zero or neutral position or to lowest point of travel and e-stop and/or power down as appropriate, before performing maintenance. Use mechanical supports for parts of rig if or while there is a risk of these falling under gravity. When safe to do so consider unmeshing axis gear drives where this facilitates safer maintenance and testing. (Observe correct procedures for such disengagement and re-engagement).

5.2.1 SOFTWARE

FLAIR software is subject to revision and enhancement. Loading of FLAIR a new from any source must be to the standard procedure on the e-stopped rig followed by verification of its version and correct functioning. Loading the software configurations is a separate procedure that must be completed to make the rig ready and safe to run. If these configurations have not been established, this requires a detailed procedure.

Record in the maintenance log the fact of loading a new FLAIR version. Avoid any risk of reverting to an earlier FLAIR version or earlier configuration as these may be incomplete or incorrect. Take especial care when more than one version is in use for different shoots as both must be maintained and not confused. Where more than one configuration is used, care must be taken to ensure that all changes to the system match the configuration chosen.

5.2.2 ELECTRONIC HARDWARE

Warning: static sensitivity:-
Axis Boards and boards in the root unit are sensitive to static electricity and require extra caution when handling. Wear a grounded wrist-strap when holding and changing these boards.

CIRCUIT BOARDS
Do not remove any circuit board (or cable) from the powered system, except strictly by the relevant procedure on the inactive system . It is safer to fully power down the rig first. The e-stop will temporarily remove the higher DC voltages from amplifiers (perhaps needing a short time for capacitors to discharge). Always verify correct operation after removing and refitting circuit cards.

AMPLIFIERS

As a minimum, ensure the rig/model mover is kept e-stopped (e-stop unit depressed) to remove motor power voltages. Confirm no green LED's on axis card or amplifier. The amplifier can then be removed and replaced by an identical one (**same voltage**: 200 or 140 or 60, **same current rating:** 14/28 or 10/20 or 8/16 or 4/8 or special 2/4 and **same** or original **personality header** (resistors). Do not insert an amplifier when not e-stopped. Keep to the identical amplifier in any particular slot. Ensure the motherboard and connectors remain in place and fully connected (To change an amplifier slot for different use requires a special maintenance procedure). Check system operation

DRIVER RACK MOTHERBOARDS

These normally remain in place at the rear of the driver rack even when amplifiers and axis boards are removed. If necessary one may be replaced by extracting up to four adjacent amplifiers and re-patching the ribbon cables to the relevant motherboards. Fully power down rack and disconnect power lead. Ensure replacement motherboards are identical to those removed. Check system operation

POWER DUMP CARD

Replace by similar procedure to an amplifier. Voltage and wattage rating must be identical (200 or 140 volts, 800 or 400 or 200 watts) For power dump card located in the Power Supply Unit chassis see below for extra precautions).

AXIS BOARDS

See warning under 'HARDWARE' above re static electricity.

E-stop and then power down the system before extracting/plugging in any axis boards
Hold the axis motherboard in place while extracting the axis board. Power up and then reload FLAIR software. Check system operation.

REGULATOR UNIT in driver rack

Consult Manufacturer

E-stop, then power down system and allow several minutes for capacitors to discharge. Disconnect main power connector and all other cables to rack. Extract all circuit cards and disconnect outgoing cables. Open up rack casing to access and replace regulator unit with an identical one. Power up empty rack and verify correct rail voltages before replacing cards and connectors. Reload FLAIR. Check system operation.

DRIVER RACK

Consult Manufacturer

Only replace with an identical spare with the axes correctly labelled and all motherboards fitted and wired to suit. Power down and remove all cables (as for regulator unit). Ditto for power up/check.

HAND-HELD BOX
Disable in software before disconnecting. Connect an identical fully-tested unit. Enable HHB and test functions starting with HHB e-stop. Disable unit till next needed.

ROOT UNIT
Replace only in a fully powered down system. Use a fully tested identical root unit. With E-stop depressed, power up, load FLAIR and perform all relevant pre-checks starting with E-stop reset and then e-stop from each e-stop button.

5.2.3 MECHANICAL

General Precautions: Observe all assembly and disassembly procedures as covered in the hardware manual and in chapters 3 and 7 in this manual. Obey all safe lifting requirements and observe weights of each subassembly.

Avoid placing hands on the rig or standing or sitting on any part of the rig. Avoid any potential pinch hazard of moving rig parts. Keep all guards in place.

Mechanisms which play a part in the support of parts of or all the equipment, such as belt drives, must be replaced by a qualified person if damaged or worn. Removal and replacement requires all load to be taken off the belt etc e.g. by secure temporary support for the relevant portion of the equipment.

5.2.4 ELECTRICAL

Do not remove guards or power leads from powered up equipment. Substantial DC as well as AC voltages are present at various locations in the rig which will present a lethal hazard if it is powered up with guards or covers removed.

Fully isolate the equipment electrically before intrusive maintenance by switching off the main isolation switches and pad-locking off. Complete intrusive maintenance and replace covers and guards before unlocking and reapplying power.

6.0 Shutting Equipment Down

The operator is required to perform the following sequence of actions in order to fully shut the equipment down- e.g. at the end of a shoot or ready for dismantling.
n.b.: if dismantling, do not disconnect mains power until instructed to in chapter 7 below.

Position the rig in its zero position or a neutral position.
Fully E-stop the equipment and disengage all axes. Quit FLAIR.
Switch off mains power to the rig and model mover at the mains isolating switches.
Switch off the line of mains switches on each power supply.
Switch off the line of circuit breakers on each power supply.
Switch off mains power to the operator interface.
Disconnect mains plugs from the wall outlets.

7.0 Dismantling, Storing and Transporting Equipment

7.1 The equipment is designed to dismantle to the units listed in section 3.5. The dismantling sequence is the reverse of that in section 3.5 and the same precautions apply.

7.2 Dismantling

7.2.1 *sequence : Summary*

CAUTION: DO NOT CONNECT OR DISCONNECT POWERED CONNECTORS. REMOVE POWER FIRST. SHOULD ANY CONNECTOR BE LEFT DISCONNECTED (WHERE PERMISSIBLE) IT MUST BE PREVENTED FROM SHORTING OR PRESENTING AN EXPOSED RISK OF SHOCK).

OBSERVE THE SAME LIFTING INSTRUCTIONS AS IN SECTION 3.5 IN THE FOLLOWING SEQUENCE.

a. Position the rig in its zero position or a neutral position.
Fully E-stop the equipment and disengage all axes.

b. Remove the camera lens and then the **camera** from the camera platform.

c. Remove the **head** and outer arm.

d. Fully power down the rig as in chapter 6 above.

e. remove all equipment interconnecting **cables** (as shown on drawing 3/030/0010)

f. If the **outer arm** was not removed from the main arm in step c above do this now.

g. Remove the **main arm** from the turret.

h. Remove the **lift arms** from the turret.

i. Remove the power supply and driver unit from the power supply tray and then remove the **power supply tray** from the side of the turret.

j. Remove the **turret** from the base.

k. Remove the **base** from the track.

l. Take up the **track**

m. The **operator interface** can now be dismantled and packed away.

7.3 Storing

The equipment needs to be stored in boxes or flight cases in suitable environmental conditions, or indoors in a studio-type environment (fully assembled or dismantled). The equipment must be protected from ingress of dust and moisture etc which would affect the internal components.

7.4 Transporting the Equipment

The dismantled rig is best transported in customised flight cases. These should be labelled with their weight and orientation plus any special lifting instructions. The majority require several people to lift them and need care to ensure they do not topple when lifted due to offset centre of gravity.

The cases and separate items require secure tethering for transportation.
The equipment must not be subjected to any high impact that could damage or distort the parts.

8.0 Modifications to the Equipment and Unusual Use

8.1 The equipment is designed to operate as a complete system with all safety features operational. All uses and configurations must be limited to those defined by the manufacturer and within the scope of the user manuals. Modifications to the equipment by the owner or user are only permitted where these clearly have no effect on the system design and its routine operation plus its full set of safety features. The manufacturer must be consulted in regard to any proposed modification that might affect the basic system or its safety features. It is the responsibility of the owner to control all modifications per the above.

8.2 Use of the equipment other than for the use intended or in the ways intended by the manufacturer, is outside the scope of this manual or the safety features and procedures established. It is the responsibility of the owner and user to make proper and correct use of the equipment in a safe manner.

8.3 In cases where the owner and user elect to use the equipment somewhat beyond the normal scope (e.g. in environmental conditions that could affect the equipment and its safety adversely) it is essential that the owner and user establish and use extra operational procedures and safety precautions as needed.

9.0 Other Equipment and Systems

(future: more detail will be provided regarding other MRMC rigs)

The safety features described in this manual are found in the MILO mark 3 and later motion control rigs. All the safety features listed are to be checked. If any are not present or are not fully functional consult the factory.

The relevant safety features can be checked per this manual when using other MRMC rigs including

Earlier versions of MILO
CYCLOPS
PANTHER DOLLY controlled by FLAIR

In these cases the user must take full account of any omitted safety features and the consequences of this. It is the policy of MRMC to offer all safety features as far as practicable. The factory will advise on upgrades where appropriate.

CYCLOPS:-
The track presents greater trip hazards as well as collision hazards. It is important that the track is boarded across between the rails to reduce the hazards of tripping and falling when crossing the track. It is not safe to stand on or near the track when a move is imminent or in progress.

Appendix A

Reference Materials

Flair Software Manual

DRAWINGS

3/000/7004	iss. 2	Axor Minispeed Amplifier
4/000/7007	iss. 1	Axis Board Overview
3/030/0010	iss. 2	Milo Mains Connections
4/900/6013	iss. 1	110v/240v ac changeover
3/900/6019	iss. 1	ESTOP operation
3/930/0011	iss. 1	Milo Overview
3/930/5112	iss. 1	MILO IIIb Electronics System Family Tree
3/930/6007	iss. 1	Milo Cable Set

SAFETY DOCUMENTATION

i	Essentials of Health and Safety at Work		HSE
ii	Work Equipment		HSE
iii	Manual Handling		HSE
iv	Safety of Machinery	BS EN 292	BSI
v	Safety of Machinery Electrical equipment of machines	BS EN 60204	BSI
vi	BS 5304: 1988 Code of practice for safety of machinery		BSI

vii Electricity at Work Regulations 1989
(wall chart)

viii Factories Act 1961
(wall chart)

ix Office, shops and Railway Premises Act 1963
(wall chart)

x Personal Protective Equipment at Work regulations 1992